Use of High Resolution Geophysical Methods for Investigating the Distribution and Impacts of Remediation Amendments in Subsurface Media

Susan S. Hubbard, Lawrence Berkeley National Laboratory; Ken Williams, Lawrence Berkeley National Laboratory; John Peterson; Lawrence Berkeley National Laboratory; Boris Faybishenko, Lawrence Berkeley National Laboratory; Jack Istok; Oregon State University; Andreas Kemna, Juelich GmbH; David Watson; Oak Ridge National Laboratory; and Anna Willett; Regenesis, Ltd; Steve Koenigsberg; Regenesis, Ltd.; Terry Hazen, Lawrence Berkeley National Laboratory.

Abstract

Development of efficient strategies for subsurface contaminant remediation requires an ability to predict or monitor the distribution and impact of remediation amendments in soils and groundwater. Prediction of such processes is currently difficult for two reasons (1) Heterogeneity of hydrogeological, and redox zonation parameters occurs on multiple spatial scales and greatly influences the distribution of remedial amendments; and (2) Biogeochemical and hydrological transformations in soils and groundwater, caused by remediation amendments, lead to alterations in the subsurface media, such as the dissolution and precipitation of minerals, surface complexation, gas evolution, changes in soil water and oxygen levels, sorption, attachment/detachment, oxidation and reduction, biofilm generation, and changes in permeability and porosity. However, our limited understanding of natural and remediation-induced variability and of coupled biogeochemical and hydrogeological processes renders prediction of the efficacy and sustainability of bioremediation extremely challenging. In this presentation, we will review results from two field-scale experiments where we have used time-lapse geophysical datasets to assess the distribution and impact of injected amendments in groundwater.

The first study focuses on a field-scale biostimulation investigation experiment in the saturated sediments of the 100H area of the Hanford Site in Washington. At this site, Hydrogen Release Compound (HRC; Regenesis, Ltd.) was injected via a single well into Cr(VI)-contaminated groundwater. When applied to a chromium contaminated aquifer, HRC stimulates the microbial community to generate the reductant H, which reduces dissolved Cr(VI) to a insoluble chrome complex of Cr(III), which then precipitates on solid particles. Crosshole radar and seismic tomographic data were collected before, during and after the HRC injection in groundwater, using the injection, upgradient, and downgradient wells. These high spatial resolution data are being used to illustrate the distribution of the HRC between the wells over time and direct borehole measurements to investigate the system response to the stimulation.

The second experiment was performed at the DOE Field Research Center of the Oak Ridge National Laboratory in Tennessee, where fractured saprolite is overlain by fill. At this site, ‘push-pull’ tests are being performed to determine in situ kinetics of microbially-mediated uranium reduction. The push-pull approach consists of injection of a prepared aqueous test solution into the saturated subsurface, followed by the extraction of the test solution/groundwater mixture from the same location for subsequent analysis of the amendment impact. Crosshole radar, seismic, and complex electrical data were collected before, during and after injection of ethanol, using two wells located on either side of the push-pull well location. The geophysical data suggest that both the amendment distribution and the system responses are strongly influenced by subsurface heterogeneity.

Our research suggests that high-resolution geophysical methods hold significant potential for visualizing the distribution of the amendments emplaced into natural subsurface systems and for investigating how the system responds over time to the treatment. These tools can be useful for validating predictive models at the field scale and in the presence of natural heterogeneity, and for monitoring the efficacy of remediation treatments.